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ABSTRACT

A study investigated the relationship between formal and conversational logic. Thirty-two male and 32 female college students evaluated the conclusions of conditional syllogism and participated in an interview adapted from Deanna Kuhn's (1991) monograph, "The Skills of Argument." Students were asked to provide explanations for several problems of interest to them, such as drinking problems, pregnancy, and college tuition. After providing a theory, students were asked to imagine the proof that would support it, and to specify the kinds of evidence that would refute their theory. Then they were offered an alternative theory, which they were to try to refute and then do the opposite--describe the evidence that would support it. Results supported the premise that reasoning in discourse is the same type of reasoning people employ in logical tasks if given the opportunity. But while the data show a relation between two contexts in mature reasoners, they do not illuminate the nature of the relation nor its developmental course. There three possibilities: (1) that both conversational reasoning and formal logic reflect the development of logical skills that are present prior to the advent of language and which will continue to develop; (2) that language plays a constitutive role with the emergence of conditional reasoning; and (3) that language and formal logic are mutually constitutive. The meanings language conveys enable representation of the premises, and the syntax enables coordination. Contains 13 references. (AA)

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Does Conversational Reasoning Contribute to Formal Reasoning Skills?

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This paper is based on a presentation in a symposium at the Meetings of the International Society for the Study of Behavior and Development, Aug. 16, 1996 in Quebec City, Canada. This version benefitted from comments and issues raised by the panel members, Jim Byrnes, Henry Markovits, David Moshman, and Leslie Smith. Thanks are also due to my interviewers and scorers, Alyssa Garber and Carolyn Acevedo-Rodericks.

Does Conversational Reasoning Contribute to Formal
Reasoning Skills?

Here is a conversation between a three-year-old and his father (Scholnick & Wing, 1995).

Father: If I do it wrong, then you'll yell at me.

Son: I'm not going to yell at you for doing it
right.

In the next a child provides the inference first and then explains how he reached his conclusion.

Birds think monarch butterflies taste yucky. If birds liked to eat monarch butterflies, they would eat it (a dead butterfly) all up. But they didn't, they didn't eat it all up.

In each excerpt, the child denies the consequent clause of an initial conditional premise and then proceeds to deny the antecedent. These three-year-olds produce modus tollens arguments. In conversation between children and their parents, and between clients and therapists there are dozens of conditional inferences (Scholnick & Wing, 1995). See Table 1. But depending on the content, even college students make frequent errors in formal reasoning tasks.

Table 1

Often the disparity between early competence in natural environments and less competent performance in the laboratory is

handled by discounting one set of data on semantic, pragmatic, and contextual grounds. Conversational reasoning is considered a poor index of logical competence because the child does not reason on the basis of a set of explicit rules but relies on knowledge of butterflies or parental behavior to make deductions. Alternatively, the child evokes a pragmatic schema or the inferences invited by threats to draw conclusions. Thus children may be intuitive logicians making automatic inferences but they lack the formal, coherent rule structure that propositional reasoning requires (Byrnes, 1988) or the metalogical awareness that distinguishes formal deduction from mere inference (Moshman, 1995). Some of these same deficits in knowledge or in a self-conscious analytic approach also explain the abysmal performance of college students.

Moreover, the deductions children make arise in contaminated territory. There is often support from an adult conversational partner, and the reasoner chooses when to make deductions rather than make deductions on demand. Conversationalists don't use the same premise to generate the whole set of valid inferences, modus ponens and modus tollens, while rejecting the possibility that when an antecedent is denied (DA) or a consequent affirmed (AC), no conclusion can be drawn. They rarely note that the same results can arise from different causes (Scholnick & Wing, 1992).

Alternatively the laboratory setting is written off also on semantic, pragmatic, and contextual grounds. The setting makes

unnatural demands on reasoners. The material presented is abstract, unfamiliar, or meaningless. Individuals are not reasoning for their own purposes, but those of the investigator. The impoverished interpersonal and cognitive context disengages the reasoner (Bronfenbrenner, 1977). People reason well in a meaningful environment, but the abstract content and context in which laboratory tests of propositional reasoning are conducted mask those skills. Even adults require meaning to encode information and process it to produce deductions.

When logical reasoning is thought to reflect a syntactic process measured in the laboratory and conversational reasoning is characterized as a semantic, contextual exercise, study of the two domains is divorced from one another. Yet theorists, such as Johnson-Laird(1983), implicate semantic representation as the foundation of logic. Martin Braine (1990), too, suggested that reasoning evolves from attempts at integrating discourse. Psychologists ignore the field of rhetoric including some famous cases of conversational reasoning. The Socratic method includes posing conditional statements and then examining cases that support or refute them.

The separation of research on conversational inference and formal deductive inference has always puzzled me. Why would the individual have two independent systems of logic, each with a different developmental course and each driven by different sets of mechanisms, one system based on semantics and pragmatics, and a second system derived from the construction of abstract devices

for achieving consistency and coherence? Isn't this carrying domain specificity too far? Perhaps the two sites for logical inference are related. At the very least, if one postulates that reasoning is based on schemas for representing social exchanges or social rules or cause effect relations, then independent assessment of the individual's knowledge base as revealed in conversation would substantiate the claims. Are the event schemas that children discuss frequently the same ones postulated to organize child and adult inferences? In the work described here, a second strategy is adopted, comparing formal and informal reasoning about similar content.

In the following study, 32 male and 32 female college students evaluated the conclusions of conditional syllogisms and participated in an interview adapted from Deanna Kuhn's (1991) monograph, The Skills of Argument. We asked students to provide explanations for several problems of interest to college students: Why is it so hard to lose weight? Why do college students drink so much? Why was there such a high rate of teenage pregnancy? Why was the cost of college tuition rising so precipitously? After providing a theory, students were asked to imagine the proof that would support it. Then they were to specify the kinds of evidence that would refute their theory. We then offered an alternative theory which they were to try to refute and then to do the opposite, describe the evidence that would support it. So students attempted to prove and disprove two explanations (their own and another person's) in each of four

content areas. They also rated their knowledge of and interest in each area on a five-point scale, where 5 is the high end.

The formal task consisted of written presentation of 16 conditional problems, created by combining each of the four logical forms, MP, MT, AC and DA, with each of the four topics: weight loss, drinking, teenage pregnancy, and tuition. My example again uses modus tollens:

If there are many bars near campus, students drink a lot.

There is very little drinking at Pine Rock College.

Are there many bars near the campus?

The students were given three alternatives: Yes, no, or not enough information to tell.

In conditional logic, the antecedent clause is the sufficient but not necessary condition for the consequent clause. The two determinate inferences, modus ponens and modus tollens reflect necessity. The presence of the antecedent necessitates the presence of the consequent. The absence of the consequent necessitates the absence of the antecedent. Proofs of theories exploit the same logic. When the cause is present so is the effect. When the effect is absent, so is the cause. An explanation is disproved if the putative cause is present, but not the effect.

So we scored students' proofs of their theories by the way they marshalled external evidence for the covariation of cause and effect. For disproofs, we examined whether individuals found

cases where the cause and effect were uncorrelated. We then evaluated the relation between use of a covariation strategy to prove or disprove a causal theory with performance on formal conditional logic.

Here are some examples of responses to the hypothesis that students drink heavily in college because they are suddenly free from parental supervision.

The first answer provides a full covariation proof, when the cause is absent so is the effect; when the effect is absent so is the cause.

"if they drank less in high school...compared to when they get into college, it seems a possibility."

Students also offered partial proofs, usually co-occurrences of the cause and effect, and less often instances where both the cause and effect were absent.

Covariation disproofs searched for instances where the cause did not covary with the effect. The most telling strategy cites cases where the cause occurs but not the effect: college fraternities with a low incidence of drinking.

"I would probably try to find out how many kids that are in a fraternity system, that would be a really good demographic area for high drinking and that don't live with their parents. I would spot light [drinking] fraternities.

Other disproofs attacked the necessity of the causal explanation. The cause is absent, people living at home, but the

effect is present, drinking heavily. So freedom from parental supervision might be a sufficient, but not a necessary cause of drinking.

"There are commuters that have parental supervision...that still do it and they have to go home to their parents every night."

In summary, the covariation proofs showed cases of covariation and the covariation disproofs pointed to cases where the cause and the effect were dissociated.

These were not the only answers given. Sometimes reasoners focused solely on the cause, ignoring its relation to the effect. To prove their theory, they argued that the cause exist. It is true that college students are away from parental supervision. In disproving a theory, they denied the existence or strength of the causal factor. Most parents are laissez-faire. They do not provide supervision. No external evidence was provided. Or they devised a story explaining why the cause is linked to the outcome or, conversely, that casts doubt on the link.

"The people that don't commute...would probably be the ones that would be doing more drinking, because they don't have to be in at a certain time, they don't have to worry about their parents."

We call these arguments existence strategies.

Finally some students asserted that any alternative explanation would disprove the first explanation. "You could tell me college students drink heavily because of peer pressure."

These categories accounted for 94% of the attempts to prove a casual theory and 91% of the attempts to disprove theories. In the remaining interviews, students either drew a blank or cited authorities. "If a psychologist says it's true, I'll believe it."

Insert Table 2 about here

Table 2 summarizes the distribution of answers in the interview protocols. As in the Wason selection task which requires disproving a rule (Evans, Newstead, & Byrne, 1993; Wason, 1966), watertight covariation proofs and refutations are infrequent, accounting for 13% of the answers. But 43% of the students gave partial proofs, citing cases where the cause and effect co-occurred and 26% gave partial disproofs citing cases where the effect occurred but not the cause.

Students' performance on the formal conditional reasoning tasks was better on the two problems that affirmed a part of the initial premise, modus ponens (62% correct) and affirm the consequent (68%) than on the two problems containing denials, denial of the antecedent (55%) and modus tollens (45%) which denies the consequent, $F(3, 186) = 4.69$, $p < .003$. The average rating of interest in each topic was 3.98 and the average knowledge rating 3.28.

We turn now to the question that motivated the study. Are the two types of reasoning related? Factor analysis was used to answer this question. Due to the large number of measures and

categories, correlations were computed to derive some composite measures. On the formal logic tasks, correct responses on the two determinate problems were highly correlated, $r(62) = .62$ so their scores were summed. Similarly, responses to the two types of invalid syllogisms were correlated, $r(62) = .67$ so these two scores were summed to constitute the second measure of formal logic. During the interviews, use of a partial or full strategy were correlated with another, $r(62) = .42$. Therefore two composite scores were computed, for covariation proofs and disproofs. Rating of knowledge and interest were also entered into the analysis. Thus there were six measures: interest and knowledge ratings, performance on determinate and indeterminate syllogisms, and covariation proofs and disproofs. Each of these scores is logically independent of the rest and the composites are psychologically meaningful.

A principal components factor analyses was performed in order to determine commonalities among the measures. See Table 3. Two factors explained 56% of the variance. The first factor, which accounted for 35% of the variance, confirmed the contention that formal and informal reasoning overlap. Performance on the valid syllogisms, as well as covariation proofs and disproofs loaded positively on this factor, as did students rating of their knowledge. The invalid syllogisms loaded negatively. Perhaps these students saw both sets of tasks through a biconditional lens. There was a single cause with a single effect. The informal reasoning tasks also loaded on a second factor

accounting for 21% of the variance. So did low interest and less knowledge of the topic.

Insert Table 3

Two questions prompted a second factor analysis. What was positively associated with performance on the invalid syllogisms? What accounted for the other types of reasoning on the interview? We had been unable to put both the covariation and noncovariation strategies in the same analysis because the choice of one strategy precluded the other. In this second analysis, knowledge and interest ratings, and scores on determinate and indeterminate syllogisms were entered, as well as the number of existence proofs and existence disproofs. Choice of an alternate theory as a disproof was also entered. These data appear in Table 4.

Insert Table 4 about here

Three factors with eigenvalues exceeding 1.0 accounted respectively for 28, 22, and 17% of the variance. The first factor characterizes students who say they are not very conversant with the topics, reason informally by seeing whether they have encountered the cause (most parents don't supervise their children) and answer syllogisms by replying they haven't enough information to tell. The second factor again attests to

the fact that students use similar strategies when proving and disproving theories, testing whether the causal factor exists. Students who adopt alternative theory disproofs cannot adopt an existence disproof in answering the same question. Hence the alternative theory disproof had a negative loading on this second factor. Instead alternative theories load on a separate factor. One might expect that students who use alternative theories as disproofs, under the assumption that only one cause covaries with an effect, would do well on determinate syllogisms, but this was not the case.

In summary, there seemed to be two approaches to each task. On the logic task, some students treated the initial premise as a biconditional in which the event in antecedent clause was a necessary and sufficient condition for the event in the consequent clause. On informal reasoning tasks these students attempted to confirm or deny the necessary connection between the antecedent and consequent. This is an entirely appropriate strategy because single cause theories are biconditional. This biconditional strategy was most prevalent in students who claimed to be very knowledgeable about the content areas. In the second approach, students claimed that the content of the premises was insufficient to draw a conclusion in a syllogism. In informal reasoning, the students evaluated the truth of a causal theory by seeking evidence of the existence of the cause without checking whether it covaried with the effect. These students rated themselves as less knowledgeable about the contents of the

problems and less interested. They tossed off the problem.

Note also that students seemed to be using the same approach across tasks. It was not unusual to find students couching their theories as conditional statements forming the major premise, their evidence as the minor premise and then drawing conclusions (Scholnick & Wing, 1995). Their success in forging proofs and disproofs was not much greater than what has been reported for the Wason task.

My claim is that reasoning in discourse is the same type of reasoning people employ in logical tasks if they are given the opportunity. This simply sounds like a repetition of the claim that errors in reasoning reflect the inappropriate borrowing of conversational skills, but backed up with conversational analyses. But I want to argue the opposite also. Successes reflect the borrowing because reasoners are very practiced in drawing conversational inferences and in arguing about the validity of statements.

How good is my own proof? This a preliminary step. If one cannot find a relation between informal reasoning and syllogistic reasoning with the same content in the same session, it will never be found. The data are confined to causals, which are treated as biconditionals in conversation, as well as in the laboratory. Conversational reasoning on evidence for statements is related to the so-called valid inferential forms but discourse does not explain treatment of the invalid forms, the ones bedeviling both reasoners and researchers on reasoning.

Moreover the data, which show a relation between two contexts in mature reasoners, do not illuminate the fundamental questions: what is the nature of the relation? what is its developmental course? There are at least three possibilities. One possibility is that both conversational reasoning and formal logic reflect the development of logical skills that are present prior to the advent of language and which will continue to develop. The elegant studies of Jonas Langer (1980) and Piaget's (Piaget & Garcia, 1991) last venture into early logic revealed the host of logical maneuvers that infants perform with objects and their understanding of contingencies. These maneuvers have the same properties of conversational inferences which tend to be isolated from one another and context- and content-bound. Development consists of coordination and abstraction. The increasing search for necessity and alternative conceptualizations throughout the course of development manifests itself in both conversational and formal tasks.

A second possibility, argued in this paper, is that language plays a constitutive role. In our studies of conversational reasoning, there was a fundamental change in reasoning once the child not only understood conditional sentences and so could argue about them, but actually produced the if-sentences themselves (Scholnick & Wing, 1995). Prior to this, most of the reasoning was either to affirm the truth of a premise (MP) or deny the connection between the antecedent. After this point, the child produced many biconditionals and modus tollens

arguments. Moreover the frequency and proportion of these complex arguments was not fundamentally different from those produced by adult speakers. Once children could produce conditional statements, they went beyond the premise which stated the existence of one connection between the antecedent and the consequent, to envision others. Not only did they know that when a cause is present, look for the effect, they knew also that when an effect is absent, look for the cause. Before they could produce conditional sentences, their arguments were reflections on another's hypotheses or statements. When they could produce their own conditionals they could then reflect on their own statements. Thus language provided a medium for coordinating clauses within a sentences and premises within an argument. It might also provide the means for coordinating different arguments which start with the same premise but negate or affirm either the consequent or antecedent.

The third possibility is that language and formal logic are mutually constitutive. The meanings language convey enable representation of the premises (Falmagne, 1990; Johnson-Laird, 1983), and the syntax enables coordination. This coordination provides a foundation for the abstraction that logic might require. In addition, because the logical meanings of connectives are more specific than the conventional meanings, the individual must develop ways of differentiating the settings in which the well honed skills of conversational inference are less appropriate than the self-consciously adopted and rigorous rules

of logic.

The study of logic is beset with a paradox. Young children do so well when reasoning in conversations. Adults perform abysmally when faced with conditional syllogisms. To unravel the paradox one must examine two contributors, situation and age. What is the developmental trajectory of reasoning in both settings? How are the two kinds of reasoning related across the life span?

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Table 1

Percentage of Inferences at Each Age Representing
Different Forms of Arguments

	Age of Speaker			
	20-36 m.	37-47m.	48-61m.	Adult
Argument form				
Modus Ponens	42	32	23	19
Contradiction	44	40	35	19
Biconditional	8	24	36	42
Modus Tollens	6	2	3	11
Indeterminate	0	2	2	9
No. Inferences	36	50	124	145

PROPORTIONAL DISTRIBUTION OF METHODS OF PROOF AND DISPROOF

	PROOF	DISPROOF
COMPLETE COVARIATION	.13	.13
PARTIAL COVARIATION	.44	.26
EXISTENCE/ STORY	.37	.21
ALTERNATIVE THEORY	—	.31
OTHER	.06	.09

**FACTOR LOADINGS OF COVARIATION
REASONING SCORES AND SYLLOGISTIC
REASONING**

	Factor 1	Factor 2
valid syllogisms (mp,mt)	+.85	-.11
Invalid syllogisms (ac,da)	-.85	+.08
covariation proofs	+.60	+.36
covariation disproofs	+.41	+.53
knowledge	+.40	-.59
Interest	+.04	-.72
eigenvalues	2.11	1.29
% variance	35	21

Factor Loadings of Noncovariation Proofs and Formal Logic Scores			
	Factor 1	Factor 2	Factor 3
MD + MT	-.88	-.06	-.12
AC + DA	+.89	+.07	+.14
Existence Proof	+.36	+.67	+.06
Existence Disproof	-.12	+.79	-.06
Alternative Theory	+.12	-.54	+.41
Knowledge	-.47	+.42	+.45
Interest	-.12	+.03	+.87
EIGENVALUE:	1.96	1.56	1.17
%VARIANCE	28	22	17

	Factor 1	Factor 2	Factor 3
MD + MT	-.88	-.06	-.12
AC + DA	+.89	+.07	+.14
Existence Proof	+.36	+.67	+.06
Existence Disproof	-.12	+.79	-.06
Alternative Theory	+.12	-.54	+.41
Knowledge	-.47	+.42	+.45
Interest	-.12	+.03	+.87
EIGENVALUE:	1.96	1.56	1.17
%VARIANCE	28	22	17